"TECH NOTES"

"TECH NOTES" is an effort by the FOSSC Materials Laboratory to share design and construction technology gained from projects done throughout WSDOT. This issue is from the Pavements Branch discussing the performance, cost and future direction of dowel bar retrofit in Washington State.

Dowel Bar Retrofit

In 1992, WSDOT constructed a test section to determine the appropriateness of dowel bar retrofit (DBR) and diamond grinding to restore the functionality of the concrete pavement as well as to provide a smooth riding surface. Due to the success of the test section, the first large-scale DBR project was constructed on Interstate 90 (Snoqualmie Pass vicinity) in 1993. Since that time, WSDOT has rehabilitated approximately 250 miles of existing concrete pavement by dowel bar retrofitting followed by diamond grinding. It is estimated that over the next 20 years an additional 1,000 lane-miles of concrete pavement may require DBR.

The average construction costs for DBR is approximately $320,000 (2001 dollars) per lane mile (includes all costs – PE, construction, traffic control, etc). The typical cost of a four-inch asphalt overlay, which is the minimum recommended overlay depth for rehabilitating a faulted concrete pavement, is approximately $375,000 per lane mile (includes all costs). DBR is considered cost effective since it is only applied to the faulted lane while an asphalt overlay would be required on all lanes, shoulders, ramps, ramp tapers, etc.

Based on the performance of the test section it is anticipated that dowel bar retrofit will extend the life of the concrete pavement by 10 to 15 years.

The following photos illustrate the dowel bar retrofit construction process.

Photo 1. Joint faulting.

Photo 2. Slot cutting (gang saw).

Photo 3. Removing slot.

Photo 4. Sandblasting slot.

Photo 5. Caulking placement.

Photo 6. Assembled dowel bars.

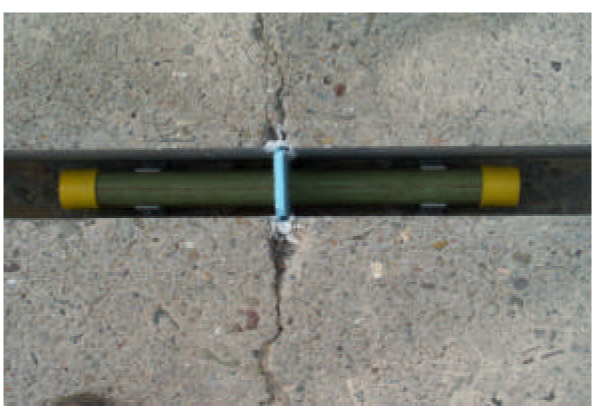

Photo 7. Dowel bar placement in slot.

Photo 8. Grout placement.

Photo 9. Grout consolidation.

Photo 10. Final product.

The dowel bar retrofit test section has been monitored annually since its construction in July of 1992. The test section included four experimental features:

- Diamond grinding only,
- Tied concrete shoulder and diamond grinding,
- Dowel bar retrofit with tied concrete shoulder and diamond grinding, and
- Dowel bar retrofit and diamond grinding.

See Figure 1 for test section layout. Data collection includes: falling weight deflectometer data for load transfer analysis (see Figure 2 for FWD testing locations), faulting measurements, International Roughness Index (IRI), and surface condition.

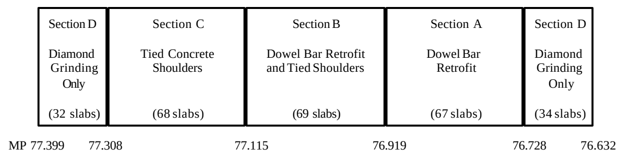

Figure 1. Test Section Layout

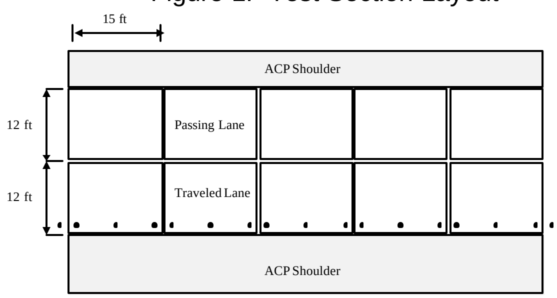

Figure 2. FWD Testing Locations

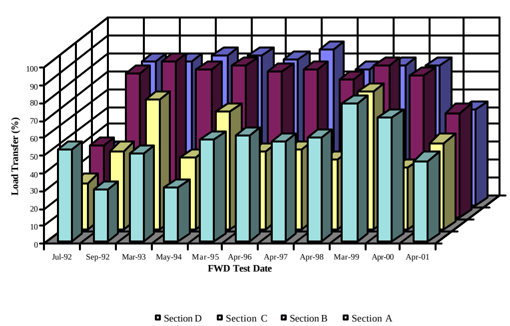

Figure 3. Load Transfer Results

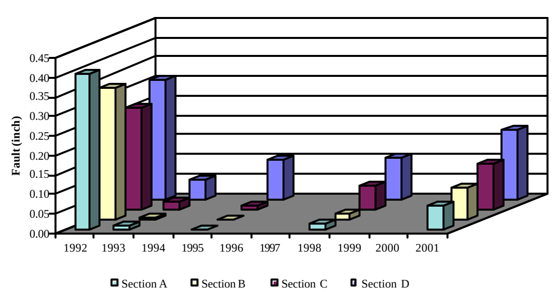

Figure 4. Fault Measurements

As shown in the above figures, the control section (as expected) and tied shoulder only sections are not performing as well as the two sections that received dowel bar retrofit. It is estimated that this section of pavement has received approximately 13,000,000 ESAL's since construction (1992 to 2001). It is apparent that the dowel bar retrofit sections (A and B) have also declined considerably from 2000 to 2001 with a reduction in average load transfer and an increase in average faulting.

WSDOT will continue to monitor this and all other sections of concrete pavement that have been retrofitted with dowel bars. Using the results from the Washington State pavement management system, it is anticipated in the near future (2 to 3 years) that performance equations will be developed that relate truck volumes to faulting such that the performance life of dowel bar retrofit can be predicted. In addition "trigger" values for concrete rehabilitation and reconstruction will also be developed. The current thinking for the trigger values are as follows (Note – slab cracking is defined as the percent of panels that are cracked into 3 or more pieces):

- If average joint faulting is < 1/8 inch and slab cracking is ≤ 10 percent – do nothing.
- If average joint faulting is ≥ 1/8 inch and < 1/2 inch and slab cracking ≤ 10 percent – dowel bar retrofit.
- If average joint faulting is ≥ 1/2 inch, slab cracking ≤ 10 percent, and ADT ≤ 50,000 – dowel bar retrofit. This criterion is established due to life cycle cost analysis in low ADT locations.
- If average joint faulting is ≥ 1/2 inch, slab cracking ≤ 10 percent, and ADT > 50,000 – reconstruct. This criterion is established due to life cycle cost analysis in high ADT locations.
- If cracking is > 10 percent – reconstruction.

The above analysis will also be supplemented with the current work being conducted by Caltrans and the University of California at Berkeley. A research project has been established in Ukiah, California where a number of concrete joints have been retrofitted with dowel bars. This research project is expected to answer the following questions:

1. Feasibility of dowel bar retrofit based on the condition of the existing slabs.
2. Evaluate the load transfer restoration provided by dowel bar retrofit.
3. Determine the expected life of dowel bar retrofit.
4. Determine the mechanism of failure.
5. Develop best practice procedures in the areas of design, materials, and construction.
6. Identify appropriate rehabilitation treatments based on life cycle costs.

For this study, Caltrans will be using the Heavy Vehicle Simulator (HVS), shown in Photo 11. Depending on the test being performed, the HVS is capable of simulating up to 20 years of heavy, inter-urban freeway truck traffic in approximately two to three months. It accomplishes this by trafficking the pavement 24 hours/day, 7 days/week, and by loading the wheel at up to 2 1/2 times that of a typical truck wheel load[1].

Photo 11. Heavy Vehicle Simulator.

A variety of tests are being conducted on this test pavement (a sampling of which is shown in Photo 12) and include, but not limited to, load transfer efficiencies, faulting measurements (shown in Photo 13), curling measurement due to temperature changes, in-place material testing, deflections, and weather information (temperature, humidity, wind speed, and rainfall).

Photo 12. Testing instrumentation.

Photo 13. Faulting Instrumentation.

The conclusions from the Caltrans HVS testing will be available sometime between fall 2001 and spring 2002.

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[1] Information obtained from the following web site - www.dot.ca.gov/dist07/announc/susie_info.htm